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## FIBER OPTIC HANDPIECE ILLUMINATION SYSTEMS

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## NOTICES

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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## FIBER OPTIC HANDPIECE ILLUMINATION SYSTEMS

### INTRODUCTION

The following report is written in three parts. Part I gives a general description of handpiece lighting systems, different available options, and advantages and disadvantages of these options. It gives an explanation of the features listed on the Comparison Chart (Table 1), and is intended to give the readers enough information to allow them to compare and make a purchasing decision on lighting units not reviewed in this report.

Part II of the report is a review of nine handpiece light systems evaluated by the Dental Investigation Service (DIS). New lighting systems are constantly becoming available and dental clinics should not feel constrained to necessarily purchase from this list.

Part III is the protocol used in this report for testing handpiece light sources.

### PART I

#### A GENERAL DESCRIPTION OF HANDPIECE LIGHTING SYSTEMS

Selection of lighting systems is limited by the handpieces currently in use by a clinic and future handpieces being considered. If the lamp is built into the handpiece, the available systems are usually limited to those supplied by the manufacturer. On the other hand, if the handpieces have a "Midwest 4-hole with fiberoptic" connector (International Organization for Standardization (ISO) 5-hole connector), the selection of available lighting systems expands greatly.

##### Types of Handpiece Couplings

Current handpiece couplings can be separated into three groups: the Midwest 4-hole with fiberoptic (ISO 5-hole), the ISO electrical, and company specific swivel connectors.

The ISO 5-hole connector is probably the one most commonly used; many handpiece lighting systems are available for this connector. The lamp may be located in the hose coupling or at a remote light box; a fiber optic bundle is used to bring the light to the handpiece.

The ISO electrical connector is a standard connector (i.e., has a standard configuration for air and electrical connections) and is used when the lamp is located inside the handpiece and is electrically connected to a remote external power source. Since this is an ISO standardized connector, any brand of handpiece with this connector will mechanically fit any brand of remote electrical power supply, but each brand of handpiece does not use the same type of lamp and, therefore, has different electrical requirements which only its remote

power supply can provide. The lamps also have a unique design and are not interchangeable. Thus, with the ISO electrical connector, you are limited to one source of handpiece lighting, that provided by the handpiece manufacturer.

The company specific swivel connectors are patented designs and limit the selection of lighting sources to their own systems. Some companies do offer adaptor couplings that allow their handpieces to be used with the ISO 5-hole connector. This option expands the selection of light sources beyond that of the manufacturer. Adding an adapter coupling will cause additional light loss. Each time light goes from the end of one fiber optic bundle to the beginning of another by crossing an air gap, there is about a 7% loss of light due to unwanted reflection.

#### Variable Light Intensity

Variable light intensity may appear to be an extravagant extra, but it is really a necessary option. It is important to choose a light source that initially has extra light capacity; then, as the handpiece ages and the fiber optic bundle darkens, the intensity can be increased, thus maintaining a constant light output. Variable light intensity also allows adjustment for the dentist's individual needs. Very long burs may need additional light (the tip of a bur protruding 7 mm from the handpiece receives only 50% of the light at the tip of a bur protruding 5 mm) and short burs need less light. The ideal light intensity at the bur is approximately between 10,000 and 20,000 lux.

#### Ratio of High and Low Light Settings

The correct ratio is determined by the light source. If the light source is very bright, a high ratio is needed to bring the initial intensity down to a reasonable value. By dividing the max light output by 10,000 lux, this ratio can be determined ( $[\text{maximum light}/10,000 \text{ lux}] : 1$ ). For instance, if a handpiece and light source combination gave an undimmed light value of 100,000 lux, then a usable high:low ratio would be 10:1, i.e., the light could be dimmed to 10,000 lux.

#### Handpiece and Light Source Maximum Light Output

The same brand of handpiece and light source is compared in Table 1. The ideal value will lie between 10,000 and 20,000 lux, approximating the level of light in the oral cavity during treatment from the dental treatment light as described by Sellers et al.\* Maximum values at or above 30,000 lux are desirable to allow for initial dimming of the light source when the handpiece is new; then, as the fiber optics of the handpiece darken with age and transmit less light, the light intensity can be turned up to the desired level.

---

\*Sellers, W.R., J.M. Young, and J.M. Powell. The scientific application of light and color to the dental environment. USAFSAM Aeromed Rev 2-78, Aug 1978.

### Percent Light Output at Coupling

These values are percentages of the brightest light tested, and are only applicable to light sources not mounted within the handpiece. Handpieces with built-in lamps are not comparable by this system and are therefore marked N/A. These values allow one to consider using a different brand light source with a certain brand of handpiece.

### Location of Lamp

The remote light box offers the advantage of very high intensity lamps. These units often use 250-watt quartz halogen projector lamps (G.E., ETJ) which are readily available. Since the lamp is remote, there is no heat generated in the handpiece or its coupling. Fiber optic guides contained within hoses are usually 3.0 mm in diameter and are interchangeable between different brands of remote light boxes (Midwest, KaVo and Lares use the same diameter; for more information see "Method of Light Activation"). A weakness in this system is the fiber optic bundle that carries the light from the lamp to the handpiece's coupling. This fiber optic bundle has the potential of slowly degrading with time, but when one considers that these light sources can deliver two to three times the light output at the handpiece's coupling that other systems can deliver, the fiber optic bundle can lose between 50-70% of its transmission and still have the equivalent illumination of other systems.

A lamp in the coupling or a lamp in the handpiece system has the advantage of no fiber optic bundle in the handpiece tubing; the tubing does contain wiring, which in certain systems must not be shortened. Due to size limitations and heating of the handpiece and hose coupling, these lamps are usually limited to about 5 watts. The operator usually will not notice heat from these systems as long as the handpiece is in operation (due to the cooling effect of the water and compressed air). If the light is used for viewing (without the handpiece in operation), slight to moderate heat may be noticed after prolonged viewing. The lamps for these units are unique quartz halogen lamps, and often are only available from the manufacturer.

### Method of Light Activation

Three systems are currently employed:

1. Handpiece Air Pressure Switch. The handpiece's drive air is used to actuate an electrical switch. In this system, the handpiece's light operates only when the handpiece is in operation. Some of these systems offer a shut-off delay, thus allowing viewing of the treatment field for about 10 seconds after the handpiece is shut off.

Another method is to operate the light source from the air line activated when a handpiece is removed from its holder (sometimes called "pilot air"); tapping into this air line allows one handpiece to be lighted whenever it is removed from its holder. Some light sources allow additional handpieces to activate the lighting system when removed from their holders.

These systems require replumbing of the dental unit's air lines to install pressure sensitive switches or additional air lines to carry air pressure to the light unit. The complexity of this installation increases with the number of switches.

2. Touch or Capacitance Switch. These systems activate whenever a handpiece is touched and remain on until the handpiece is released. The hose must have a wire running its full length to connect the handpiece and the light source. This system has the advantage of continuous viewing. For these systems to activate correctly while the operator is wearing rubber gloves, the manufacturer's instructions must be followed for the unit's preparation.

3. Switch. An additional means for some lighting systems is a switch located on foot controls, remote light box, remote control box, or even the hose's coupling. These are intended to offer extended viewing with the handpiece or may be used for other options. Location of this switch on the dental unit will dictate its practicality.

#### Number of Handpieces the Light System Will Support

It is common practice for dental operatories to be equipped with only one fiber optic handpiece coupling, usually reserved for a high-speed handpiece. Manufacturers are introducing fiber optic-equipped slow-speed handpieces, which are gaining in popularity. Therefore it would be wise to consider systems that allow for more than one handpiece.

#### Plug-in Power Unit

Some lighting systems use a miniature transformer which plugs into the dental unit's 120 (or 240) VAC outlet. In these cases, it is essential to check for proper clearance around the outlet since utility boxes inside dental units tend to be very crowded.

#### Safety Requirements

Today most electrical appliances are quite safe, but there are several indicators of proven safety. Underwriter's Laboratories (UL) approval is earned after an appliance is tested. (Underwriter's Laboratories is an independent testing organization.) These tests are extensive and very expensive for the manufacturer, and appliances that carry a UL approval seal should be considered safe. Double-insulated appliances also should be considered safe; these appliances isolate the user from the primary line voltage and eliminate the need for conventional grounding.

#### Voltage Requirements

Overseas facilities will need to select units that operate on their local voltage or plan to procure additional voltage-reducing transformers. Systems designed for use with only 60 Hz should not be used on a 50 Hz power line (i.e., Europe). Fortunately most lighting systems are 50 and 60 Hz compatible.

### Ease of Lamp Replacement

Lamp replacement is considered "easy" if no tools are required and less than three parts need displacement. "Average" difficulty is given if a screwdriver is needed and less than three parts are displaced. "Difficult" is used for all other cases.

### Availability of Curing Wand

Some handpiece lighting sources offer a composite curing wand option. For an evaluation of these items, please refer to the appropriate DIS newsletter (given in parentheses).

### Price

Prices are those in effect on the dates indicated and are the Veterans Administration (VA) prices. Where the handpiece and light are only sold together, and the handpiece can use another light source which can be bought separately, the price listed is the difference between the light-handpiece system price and handpiece price. This breakdown allows comparison pricing.

Where the handpiece will only operate with one brand of lighting system and they are sold as a set, the price is listed as N/A.

## PART II

### REVIEW OF HANDPIECE LIGHTING SYSTEMS

#### A-dec Focus System

This light source has its lamp located in an ISO 5-hole connector. Light output at the coupling is about one half the intensity of the remote light box systems. Compounding this problem is the A-dec 5130 handpiece's small fiber optic bundle (46% of the area of the Midwest Quiet-Air's bundle), which results in a very low bur tip illumination of 6,400 lux. If a different handpiece is used with the Focus system, for instance the Starflex, the light output would be in the 20,000-lux range.

The variable intensity control gives about a 2:1 ratio, which is a reasonable ratio. The control can be mounted on the handpiece hanger bar which is very convenient.

This system lacks any time delay, meaning that if you want light, the handpiece has to be in operation. The diagnostic foot control switch is meant to correct this problem; by pressing this switch the light can be activated at will. But the diagnostic foot control switch replaces the chip blower switch on the foot control, thus losing the capability of the chip blower. The diagnostic foot switch will only function with one handpiece in a two-handpiece system.

Considerable labor is needed for installation if the A-dec Focus System is installed after delivery of the dental units.

The installation and maintenance instructions are well written and illustrated.

### KaVo

#### Vicon Micro-LS System

The Vicon Micro has a 20-watt halogen lamp located in a small, remote light box connected to the handpiece via a KaVo hose and connector. This system is the lowest powered of the remote light systems (20 watts compared to 250 watts for the others) and, not surprisingly, produces the lowest light output of this group. The 10,000 lux produced at the bur tip is just within the lower limits of acceptability.

There is no time delay for the light to remain on after using the handpiece. KaVo recommends operating their lighting systems from the dental unit's "pilot air" instead of the "drive air." If a dental unit is so equipped, a handpiece is illuminated when it is removed from the handpiece holder and remains on until it is replaced.

The installation manual is sufficient, but it lacks a trouble-shooting guide and a telephone number for information. There is no maintenance manual.

Due to this unit's poor light output and high expense, it is not recommended unless its small size is paramount over all other factors.

#### LS Light System

The light source is a 250-watt lamp in a remote light box. Along with the KaVo handpieces they deliver about 40,000 lux to the bur tip; quite adequate to allow initial dimming. The dimming circuit is very smooth in its extensive range of operation.

There is no time delay for the light to remain on after using the handpiece. KaVo recommends operating their lighting systems from the dental unit's "pilot air" instead of the "drive air." If a dental unit is so equipped, the handpiece is illuminated when it is removed from the handpiece holder and remains on until it is replaced.

If a curing wand is desired, the Vicon DLS System should be considered; the curing wand has not been evaluated by DIS.

The installation manual is sufficient, but it lacks a trouble-shooting guide and a telephone number for information. There is no maintenance manual.

### Vicon DLS System

Not evaluated by DIS:

Light source: 250-watt lamp in a remote light box.

Number of handpieces system will accommodate: 2

Variable light intensity.

Will also support a curing wand (\$275.00)

System Cost: \$337.50

### Lares

#### Apollo, CS System

The Apollo System has its lamp located in a special Lares swivel connector and is, therefore, only compatible with Lares handpieces. When the handpiece is removed, the lamp is entirely exposed, making it subject to possible damage. The lamp gets very hot while in operation. If the handpiece is removed while the lamp is still hot and the lamp is accidentally touched, it will cause a burn. Mean lamp life is reported to be 35 hours.

The light intensity at the bur tip is 14,900 lux, which is an acceptable value. It would be better if the intensity were greater and thus allow for initial dimming. Later, as the handpiece's fiber optic bundle darkened with age, the light intensity could be increased.

The variable intensity control was not submitted for evaluation. The variable intensity control is designed to be mounted on a convenient surface for the operator.

The time delay for the light is 11 seconds after the handpiece is shut off.

The installation and maintenance instructions are well written and illustrated.

### Quartzfire SX System

This remote light box system utilizes a 250-watt projection lamp and is very bright. The light output, when used along with the Lares' 557 handpiece, produces 24,700 lux at the bur. This light level will allow the desired initial dimming with future capacity for increased intensity. This light system could be an improvement for some handpieces with less than ideal fiber optics (example: the A-dec 5130 yielded about 24,000 lux at the bur tip using this light source).

The variable intensity control for this system is not as described in the instructions. The system tested only allows dimming by adjusting the light guide in or out of the light box, which gives an intensity control ratio of 3:1, acceptable for the Lares handpiece and some other brands. The Midwest and Star handpieces would need more dimming, up to 10:1, to be able to dim these handpieces to the desired 10,000 to 20,000 lux range.

The system is activated by handpiece air pressure and has a light delay of 12 seconds after the handpiece is shut off.

An optional curing wand is also available (\$83.00 additional).

The installation and maintenance manuals are well written and illustrated (although slightly inaccurate).

#### Midwest

#### In-sight II System

The In-sight II has a 250-watt projection lamp located in a remote light box. This system and the Midwest handpieces yield the brightest bur tip illumination values (Tradition, 44,600 lux; Quiet-air, 87,000 lux). The bright light source combined with the collimation and high transmission ratio of the light by the handpieces account for these high readings.

The variable intensity control gives a high to low ratio of 72:1, which is necessary for this bright light source. The intensity control, with switch, can be mounted on any convenient surface.

The light is activated by touching any fiber optic equipped handpiece, and it remains on until the handpiece is released. This capacitance switch system will work with rubber gloves if it is correctly adjusted.

A curing wand is available (\$165.00).

Instruction and maintenance manuals are well written and illustrated.

#### Power Optic Lighting System

Not reviewed by DIS:

Light source: lamp in hose coupling.  
Number of handpieces system will accommodate: 3  
Variable light intensity.  
System Cost: \$286.00  
Lamp Cost: \$19.50 (3 lamp pk.)

#### NSK Phatelus C (Model NE11-120)

The lamp is located inside of the NSK Phatelus handpiece, which uses an ISO electrical connector. This handpiece-light source combination produces an incredibly low 500 lux at the bur tip at its highest setting.

The light output on this system is so low that it is not recommended.

#### Starflex Lighting System

The Starflex system has its lamp located in the ISO 5-hole hose coupling and produces 26,000 lux at the bur tip.

There is no variable light intensity control available. A variable light intensity control would allow initial dimming and future compensation of light loss due to decreased transmission as the handpiece's fiber optics age.

There is a 7-second delay after the handpiece is shut off to allow for diagnostic viewing.

#### W & H Toplight DS 33

This system is designed to be used with the W & H Toplight handpiece and is compatible with that handpiece only. The lamp is located inside the handpiece and produces 15,200 lux. This light value should be sufficient for most applications, but may prove to be too dim as the handpiece ages and the transmission of light through the fiber optics decreases.

The high to low dimming ratio is 82:1 which should be more than sufficient for any application.

This system is activated by handpiece air pressure. There is an adjustable (1-40 sec) built-in delay that allows the light to operate independently of the handpiece. Both the delay for switching on the lamp after handpiece activation and the delay for shutting off the lamp after the handpiece shuts off are variable. There is also a contact switch on the hose coupling that allows activation by touch. This contact switch relies on electrical conduction (low voltage circuit of 5 volts) and would not work while wearing gloves.

Installation and maintenance instructions are in small print and have very brief descriptions and somewhat busy line drawings.

#### DISCUSSION

By examining the graph "Handpiece and Its Brand Light Source" (Fig. 1), it can be noted that only the Midwest<sup>1</sup> and KaVo<sup>2</sup> handpieces with their own light sources provide the best handpiece illumination (i.e., over 30,000 lux).

If the Star handpiece's built-in light source is replaced with a 250-watt remote light source system (e.g., In-sight II, but any of the 250-watt projector lamp systems would work as well), then the Midwest, KaVo, and Star handpieces provide the best handpiece illumination (Fig. 2).

The Lares and A-dec handpieces are initially acceptable, but they lack the reserve light intensity needed to deal with fiber optic aging. The NSK handpiece is clearly not acceptable.

The Starflex, Lares<sup>3</sup>, and W&H light systems offer initially acceptable lighting, but will not be able to supply additional light as the handpiece's fiber optic bundle dims with age. The A-dec<sup>4</sup> and NSK light systems are not acceptable.

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<sup>1</sup> With In-sight II

<sup>2</sup> With the Vicon LS

<sup>3</sup> With the Quartzfire SX

<sup>4</sup> When used with the A-dec Handpiece #5130

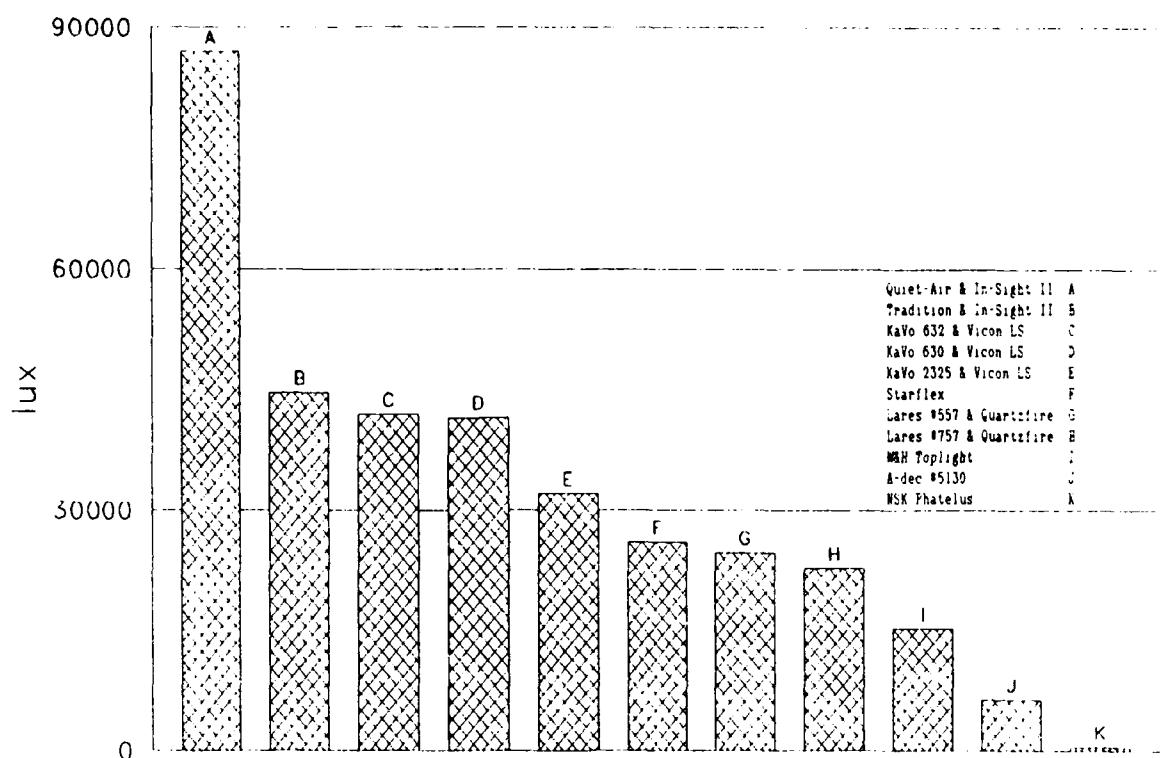


Figure 1. Handpiece and its brand light source.

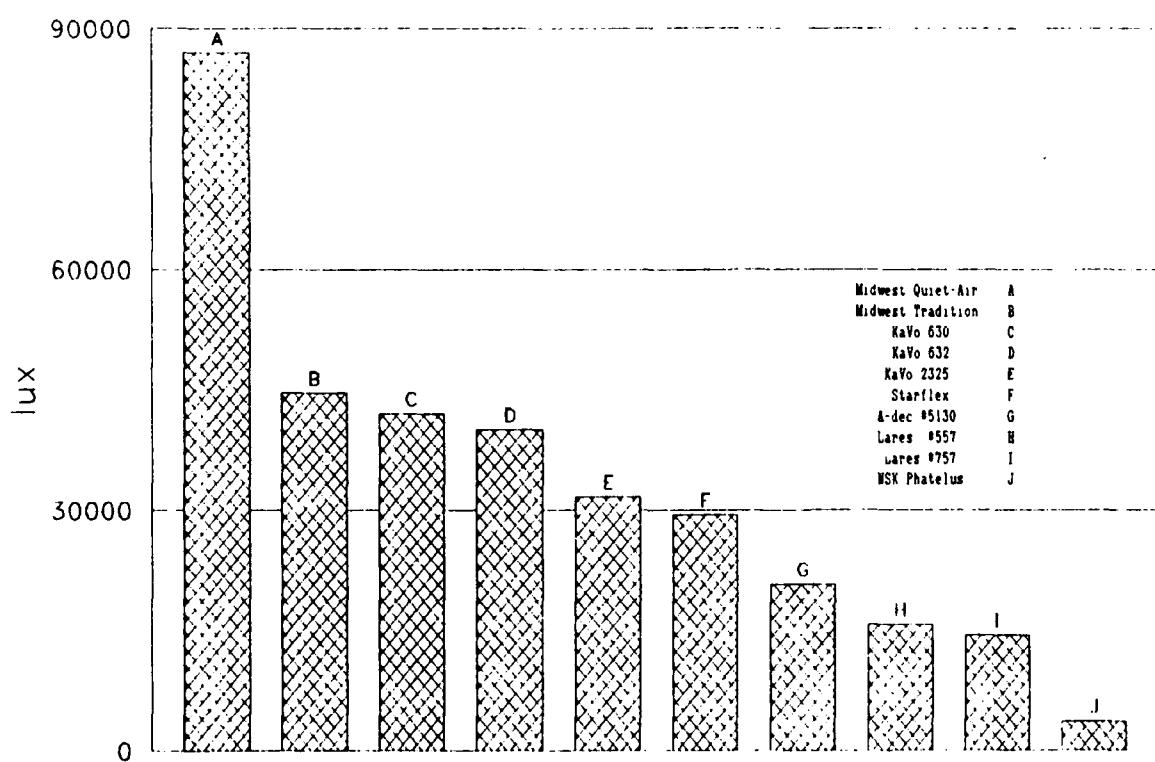


Figure 2. Handpiece light using common light source (In-sight II).

The overall best handpiece lighting systems are the 250-watt remote light source systems. See Figure 3 for a comparison of all the handpieces and light systems tested.

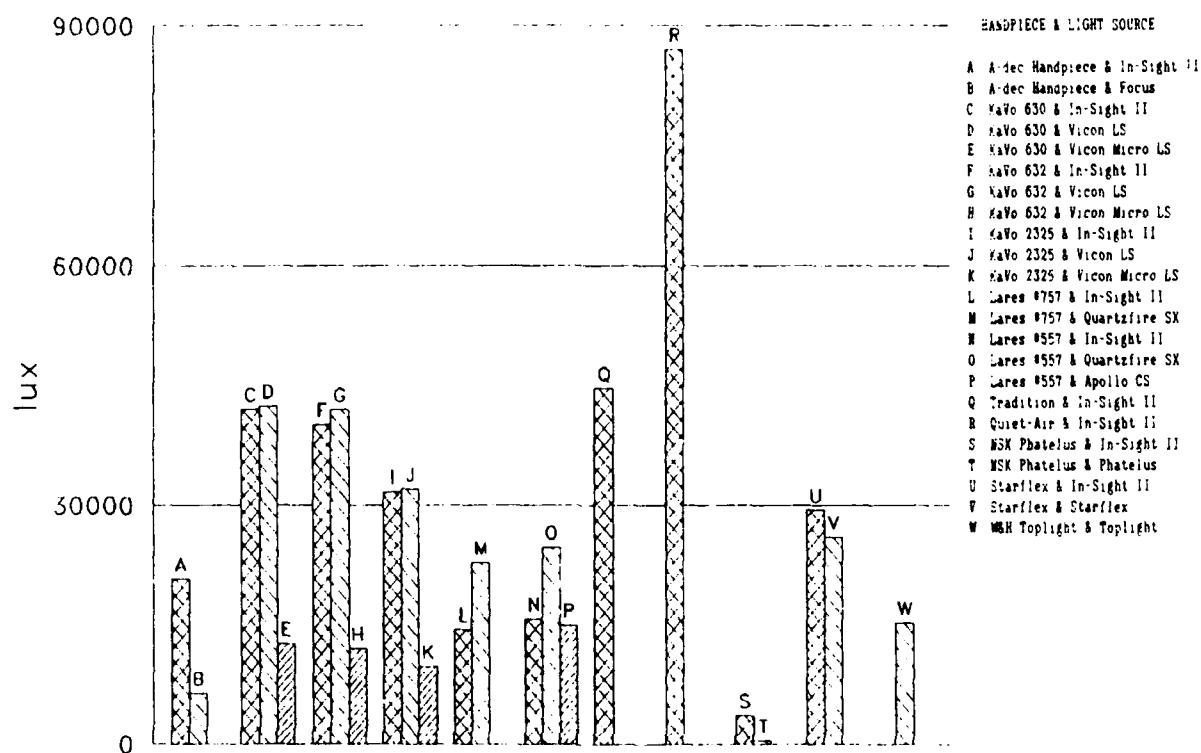


Figure 3. Light output.

The 250-watt remote light sources provide the highest light output and flexibility. When the handpiece lighting system is new, the variable intensity control can be turned down to reduce the high light intensity to the recommended 10,000-20,000 lux. As the fiber optic bundles darken with use and don't transmit as much light, the variable intensity control can be turned up to increase the illumination to the proper level. This flexibility is lacking in the lower wattage handpiece lighting systems.

### CONCLUSIONS

The most desirable handpiece lighting systems evaluated by this study, are the Midwest In-sight II and the KaVo Vicon LS light sources. The Lares Quartzfire is also acceptable if it is not used with the Midwest or KaVo handpieces due to its limited dimming capability.

If remote light source systems cannot be utilized due to severe space or power limitations, the A-dec and Starflex systems may be considered.

## PART III

### PROTOCOL FOR HANDPIECE LIGHTING SYSTEM EVALUATIONS

The lighting systems were evaluated against the checklist (Evaluation of Handpiece Light Sources).

Difficulty of lamp replacement was determined by the following:

EASY -- if no tools were required and less than three parts needed displacement.

AVERAGE -- if a screwdriver was needed and less than three parts were displaced.

DIFFICULT -- for all other cases.

Intensity of light at the coupling was measured with a Gossen Ultra-Pro light meter with a Luna-Sphere attachment by placing the coupling in contact with the flat diffuser and positioning it to give a maximal reading.

The intensity of light at the tip of a 557 bur was made using a Spectraspot photometer PR1500. The handpiece was positioned in a milling jig so that the tip of a 557 bur would be in the same plane as the surface of a barium sulfate reflector. The bur was removed. The spot meter was calibrated and adjusted to read a 4-mm-diameter area on the surface of the barium sulfate reflector. The handpiece was adjusted parallel to the surface of the reflector to obtain a maximal reading, and the value was recorded. Then the light source was dimmed to its lowest intensity, and the value was recorded.

## EVALUATION OF HANDPIECE LIGHT SOURCES

Name:

Date:

Government Cost:

Manufacturer: (Company)  
(Address)  
(Telephone)

Serial Number:

### Photographs

Front View:

Controls (if not on front view):

Lamp Location:

Fiber Optic Bundle:

### Physical Characteristics

Size (LxWxH):

Weight:

Voltage:

Watts:

Hz:

U.L. Listed: Yes No

Fused: Yes No

Does it have a hospital grade plug? Yes No

Length of electrical cord:

### General Test Information

1. Location of lamp: In unit In coupling

2. Difficulty of lamp replacement: Difficult Average Easy

3. Type of lamp (note brand and part #):

4. Method of light activation: Touch Air pressure Switch

5. Will it activate while the operator is wearing rubber gloves? Yes No

6. How long will the light remain on after activation?

7. Can the intensity of the light be varied? Yes No  
If Yes, how many steps or is it continuously variable?

High intensity value (lux) at the coupling:

**Handpiece tested:**

High intensity value at tip of bur (557):

Low intensity value at tip of bur (557):

8. Location and types of controls:

9. Will it also support a light curing wand? Yes No

See project # concerning curing unit evaluation.

10. How many handpieces will this unit support?

11. Other comments:

TABLE 1. COMPARISON CHART

A-dec 2601 Creative Drive Nashville, TN 37213 (615) 547-1883	Kavo America Corp. 2401 W. Bassett Road Suite 1550 Hoffman Estates, IL 60195 (312) 865-3835	Kavo America Corp. 2401 W. Bassett Road Suite 1550 Hoffman Estates, IL 60195 (312) 865-3835	Lares 1581 Industrial Road San Carlos CA 91070-4195 (800) 227-9862	Lares 1581 Industrial Road San Carlos CA 91070-4195 (800) 227-9862	Midwest: Lares 1581 Industrial Road Midwest (ISO 5 Hole)	Star Dental P.O. Box 866 101 W. Linton Street Suite 111 Das Plaines, Illinois 60018-1894 (312) 362-6688	NSK America Corporation 101 W. Linton Street Suite 111 Das Plaines, Illinois 60018-1894 (312) 362-6688
Features							
Type of Handpiece Coupling	Midwest (ISO 5 Hole)	Kavo Swivel Connector	Kavo Swivel Connector Only	Kavo Swivel Connector Only	ISO Electrical (ISO 5 Hole)	Midwest (ISO 5 Hole)	ISO Electrical (ISO 5 Hole)
Is the Light Intensity Continuously Variable	Yes	Yes	Yes	Yes (not tested)	Yes	Yes	Yes
Ratio of Light High : Low Settings	2.0 : 1	10.7:1	1000:1	(not tested)	3.0 : 1	72 : 1	43 : 1
Handpiece and Lamp Light Output at Bar Tip	A-dec 6130 6,400 lux	Kavo 630 12,000 lux	Kavo 630 41,500 lux	Lares 557 14,900 lux	Tradition 44,600 lux	MSI Phatelux 500 lux	Star-Tlex 26,000 lux
Maximum Light at the Coupling	477	52	721	N/A	100%	70%	N/A
Method of Light Activation and Time Delay	Handpiece Air Pressure (is optional foot switch) 0 Seconds	Handpiece Air Pressure 0 Seconds	Handpiece Air Pressure 0 Seconds	Handpiece Air Pressure 11 Seconds	Handpiece Air Pressure 12 Seconds	Handpiece Air Pressure 3 Seconds	Handpiece Air Pressure Switch on Unit or Remote Con. N/A
Number of Handpieces Unit will Support	2 (foot switch only)	2 (option for 2)	3	4	3	2	3
Location of Lamp and Cost	Handpiece Coupling \$21.00	Remote Unit with Fiber Optics \$16.00	Handpiece Coupling \$22.00 for 3 Lamps	Remote Unit with Fiber Optics \$20.00	Remote Unit with Fiber Optics \$18.20	Handpiece Coupling \$24.55	In Handpiece
Plug-in Power Joint and Size	Yes 2.5 x 2.5 x 2.5 cm	No	No	No	No	Yes A.3 x 5 x 5 cm	Yes 10 x 5 x 4.5 cm
"Approved Double Insulated Hospital Grade Plug"	No Yes No	No No Yes	No No No	No Yes Yes	No No No	Yes Yes Yes	No Yes No
Voltage Hz Wattage	120 VAC 50/60 Hz 4.5 Watts	110 VAC 50/60 Hz 25 Watts	120 VAC 50/60 Hz 264 Watts	100-120-220-240 VAC 50/60 Hz 240 Watts	120 VAC 50/60 Hz 360 Watts	120-220-240 VAC 50/60 Hz 20 Watts	100-125-220-240 VAC 50/60 Hz 3 Watts
Base of Lamp Replacement:	Easy	Difficult	Easy	Easy	Average	Easy	Easy
Current Model Available	No	No	No	Yes	Yes	No	No
Price (Aug. 1988)	\$250.35	\$268.40	\$216.00	\$253.00	\$201.00	\$332.75	\$205.00